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CONCRETE LIGHTING POLES
A CONDITION SURVEY

MATERIALS INFORMATION
ENGINEERING MATERIALS OFFICE

CONCRETE LIGHTING POLES-
A CONDITION SURVEY

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SUMMARY

During 1984 and 1985 the Ministry carried out a field survey of the condition of 3375 concrete poles in the Toronto and Hamilton Districts. The survey showed that the majority of poles have no visible defects. About 20% of the poles showed significant cracking or spalling. The degree of damage is dependent to a certain extent on the age of the pole, the severity of exposure to salt spray and the manufacturer. However, because there are large numbers of poles over 15 years old in severe exposure conditions which show no noticeable defects, it was concluded that the initial quality of manufacture is the major determining factor in the life of concrete poles.

1. INTRODUCTION

In November 1983 the Structural Management Committee established a task force to review concerns about the deterioration of concrete lighting poles. One of the activities of this task force was to initiate a detailed study of the condition of concrete lighting poles in Districts 3, 4 and 6. This work followed from a preliminary survey of the condition of concrete poles in District 6 earlier in 1983 [1].

The purpose of this report is to describe the survey and to present and discuss the survey results.

2. CONCRETE LIGHTING POLE SURVEY

2.1 Introduction

The field survey was initiated to accurately assess the condition and levels of deterioration of in-service concrete lighting poles within the Ministry's jurisdiction. The survey was performed by District staff commencing in the early summer of 1984 and was completed by the summer of 1985.

Significant factors affecting a pole's condition include the age of the pole, the manufacturer of the pole, its exposure to salt spray and the quality of concrete. However, because of constraints on the survey it was not possible to collect information on the latter factor. Consequently, the surveyor rated the pole's condition, its exposure to de-icing salts and recorded the pole's date and name of manufacturer. The criteria used to assess a poles condition and exposure are described in the following sections.

2.2 Condition Rating

Non-destructive testing of concrete lighting poles may be performed by methods such as covermeter surveys, impact hammers, corrosion potentials or delamination surveys. These methods tend to be fairly expensive and time consuming and present some safety problems in areas of high traffic. Since most of the concrete poles to be surveyed were located in high-volume urban freeways, the task force decided that a visual assessment would be a more practical, faster and safer method of inspection. Consequently, a visual rating system was developed by the Task Force and is shown in Table 2.1.

TABLE 2.1 RATING SYSTEM FOR CONDITION OF LIGHTING POLES

RATING	DEFECTS	ACTION REQUIRED
1.	No noticeable defects in pole	No Action
2.	Rust stains from reinforcement visible in places, hair line cracking	No Action
3.	Some spalling not greater than one m^2 overall. Spalls generally not below the top of the reinforcing steel occasional cracks	Inspect Annually
4.	Spalls greater than one m^2 in total. Spalls often extending below the top surface of re-bars	Replace within 1-2 years
5.	Poles exhibiting any of the following: A. Holes in poles. B. Spalling around total circumference of pole. C. Any gap between an individual re-bar and the surrounding concrete.	Replace as soon as possible

2.3 Exposure Rating

Concrete lighting poles are particularly susceptible to deterioration from the spray of de-icing salt because of the minimal, and sometimes non-existent concrete cover on uncoated reinforcing steel. Cracking occurs, salt penetrates the concrete, reinforcing steel corrodes and eventual spalling occurs. Consequently, each pole surveyed was rated on its exposure to de-icing salt based on the criteria listed in Table 2.2.

TABLE 2.2 RATING SYSTEM FOR EXPOSURE OF CONCRETE LIGHTING POLES TO DE-ICING SALT

RATING	DESCRIPTION
A	Very severe exposure. Poles are located within 5 metres of traffic on both sides.
B	Severe exposure. Poles are located within 5 metres of the edge of the closest traffic lane on one side.
C	Moderate exposure. Poles are located further than 5 metres from a traffic lane.

In addition to the above, the surveyor collected general information on each pole such as pole identification number, highway number, pole height and contract number under which the pole was originally installed.

2.4 Scope of the Survey

In Toronto District over 2600 concrete lighting poles were surveyed. The Ministry has an estimated 2850 concrete poles within the immediate vicinity of Metropolitan Toronto [1]. Based upon this estimate the Toronto District survey included in excess of 90 percent of the poles in service. The survey included Highways 401, 404, 427 and Queen Elizabeth Way.

The Hamilton District survey consisted of approximately 740 concrete lighting poles. It is believed that this survey included virtually all poles in the District. The survey included primarily poles located on Highways 5, 25, 58, 403, 405 and 420 and Queen Elizabeth Way.

Stratford District contains 350 concrete lighting poles. Although all poles were surveyed, the data reported was incomplete with regard to the name of the manufacturer and the date of manufacture. Consequently the information collected in this survey was not included in the analysis in Section 3.

3. RESULTS OF THE CONCRETE POLE SURVEY

3.1 Introduction

Upon completion of the collection of data from the field, the survey information was entered and stored on a micro-computer in the Concrete Section for sorting and analysis purposes. Information was entered for 737 poles from Hamilton District and for 2638 poles from the Toronto District survey yielding a total of 3375 poles in the data base. Treatment of the data consisted of two distinct operations:

1. Sorting by Condition Rating, Exposure Rating, manufacturer and age in order to obtain an overview of the distribution of the poles surveyed, and

2. Analysis to determine trends and patterns in concrete pole performance.

The following sections detail the results of these two operations.

3.2 Distribution of Concrete Lighting Poles

3.2.1 Distribution by Condition Rating

Figure 3.1 presents the total number of poles within each of the five Condition Rating categories. Within Rating 1 (no noticeable defects in pole) there were 1706 poles representing 51 percent of the total poles surveyed. Rating 2 (rust stains, hair line cracking) accounted for 883 poles or 26 percent of those surveyed. Poles with Rating 3 (some spalling, cracks) totalled 659 or 20 percent while poles with Ratings 4 and 5 (extensive spalling, holes) totalled 60 poles each representing less than 4 percent of those poles surveyed. Seven poles were not assigned a Condition Rating. Figure 3.1 also shows the distribution of poles by manufacturer within each of the five Condition Rating categories.

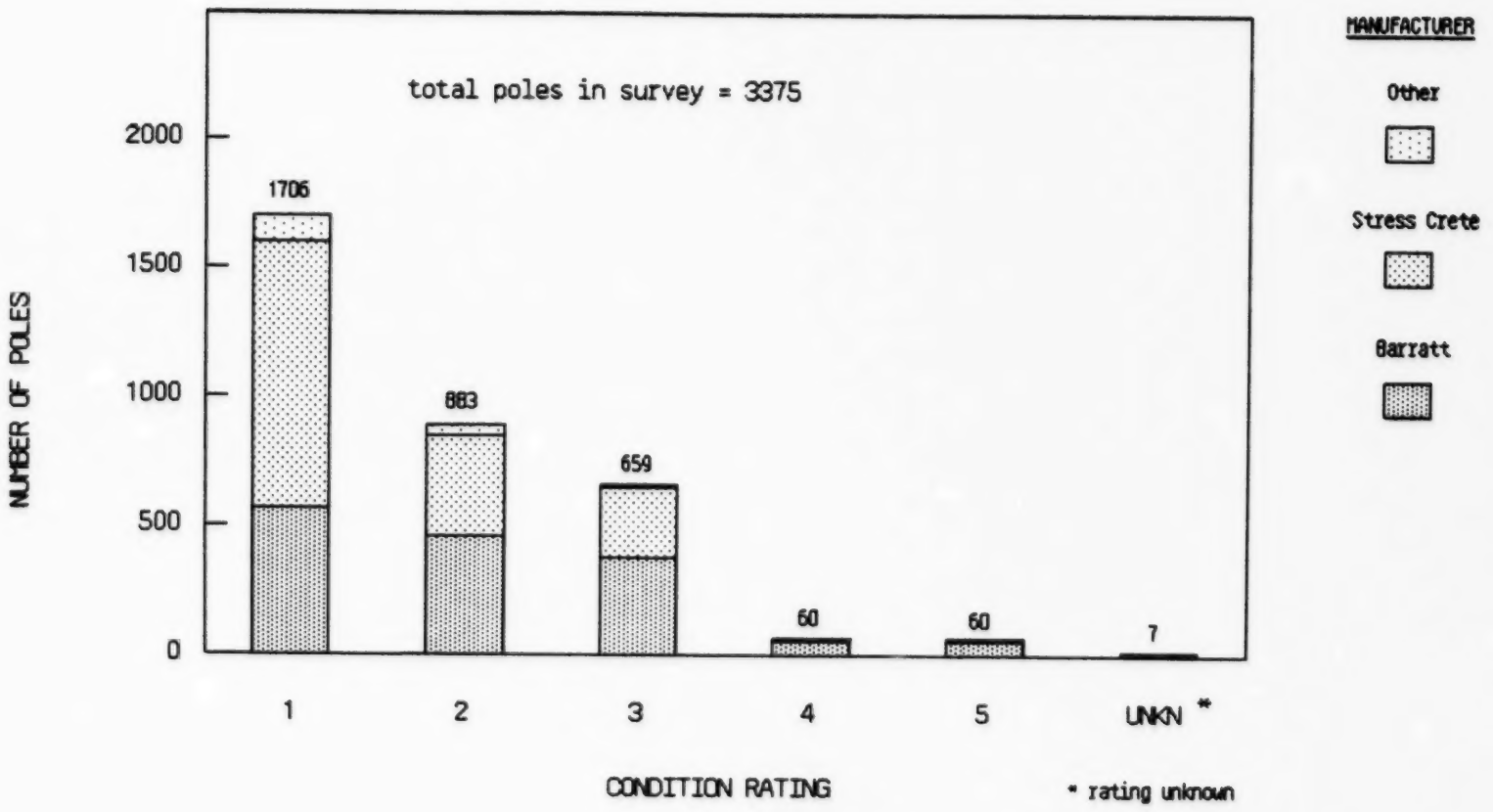

FIGURE 3.1 DISTRIBUTION OF CONCRETE POLES BY CONDITION RATING

3.2.2 Distribution by Manufacturer

Most of the concrete poles within the Ministry's jurisdiction have been supplied by two manufacturers: Barratt and Stress Crete. Figure 3.2 shows that Barratt poles account for 1511 or 45 percent of the total poles surveyed while Stress Crete poles total 1709 or 51 percent of poles surveyed. Poles other than those manufactured by Barratt and Stress Crete total 155 and include 83 poles manufactured by Central Precast Products. In 2 percent of the cases the manufacturer could not be identified because the pole identification plate was missing.

3.2.3 Distribution by Exposure

The poles surveyed were sorted by their Exposure Rating resulting in the distribution shown in Figure 3.3. Exposure Rating A (very severe) accounted for 1342 poles, 40 percent of the poles surveyed. Exposure Ratings B and C totalled 1633 (48 percent) and 58 (2 percent) respectively.

Upon commencement of the field survey the Exposure Rating system had not been established by the Task Force. Once it was developed, the Hamilton District survey was complete and the Toronto District survey was well under way. Consequently, Exposure Ratings were applied to poles in Hamilton District by examining electrical drawings. In Toronto District the Exposure Rating was applied to all subsequent poles surveyed and a number of previously surveyed poles were re-examined in order to apply an Exposure Rating. The poles that did not receive an exposure rating are shown in Figure 3.3 under the heading "Unknown". Although these 342 poles represent 10 percent of the total poles surveyed it was felt that the remaining poles provided a large enough sample size to adequately examine patterns and trends relating to a pole's exposure to salt spray.

3.2.4 Distribution by Age

Figure 3.4 presents the distribution of the 3375 poles surveyed by their age. The largest number of poles fall into the 18-20 year category with 1304 poles, representing 39 percent of the total. This age group corresponds to the major reconstruction of the Toronto area urban freeway system in the mid 1960's. Poles between the ages of 12 and 20 years account for approximately 81 percent of the poles surveyed. Poles less than 12 years old and poles greater than 20

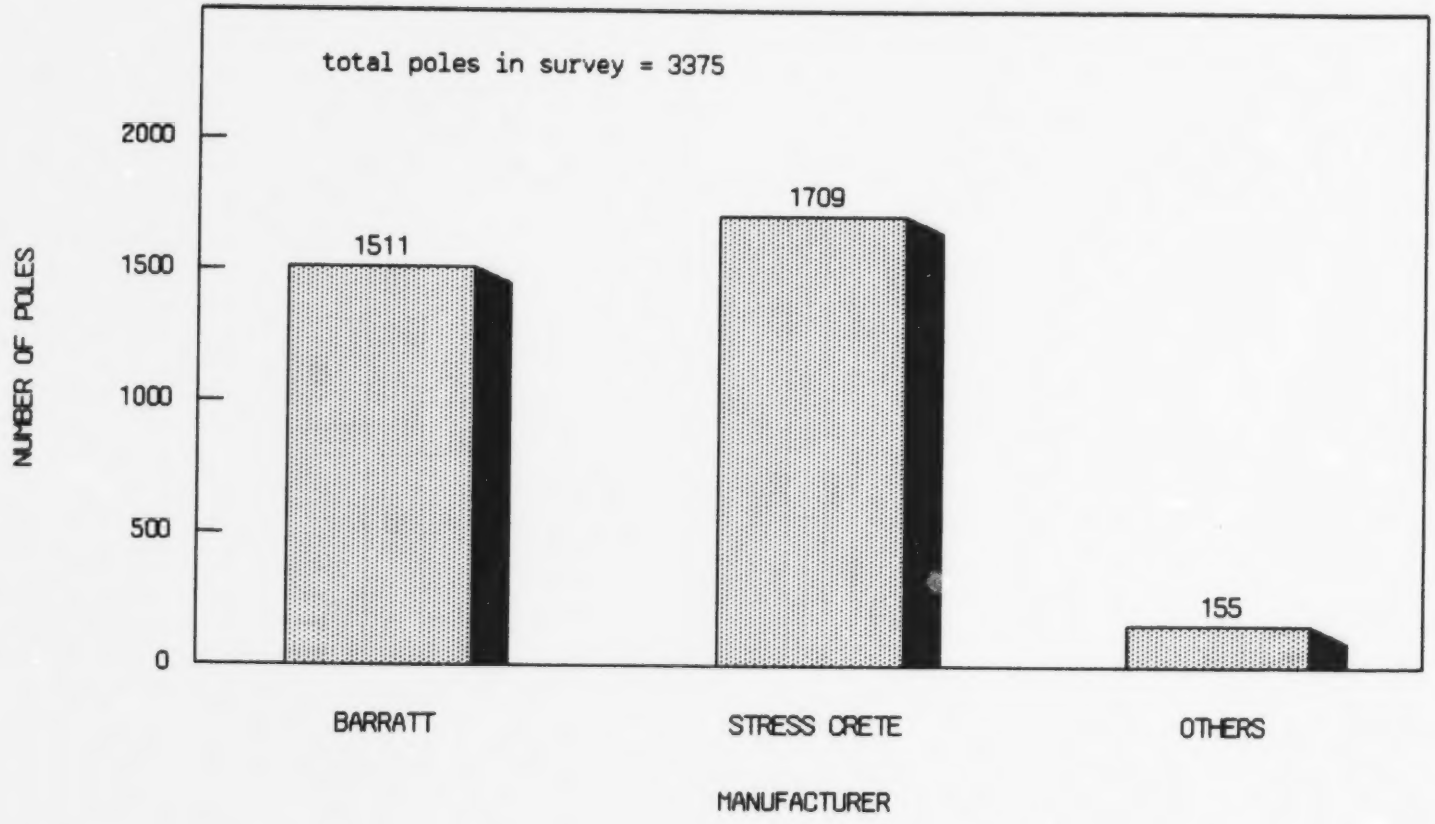

FIGURE 3.2 DISTRIBUTION OF CONCRETE POLES BY MANUFACTURER

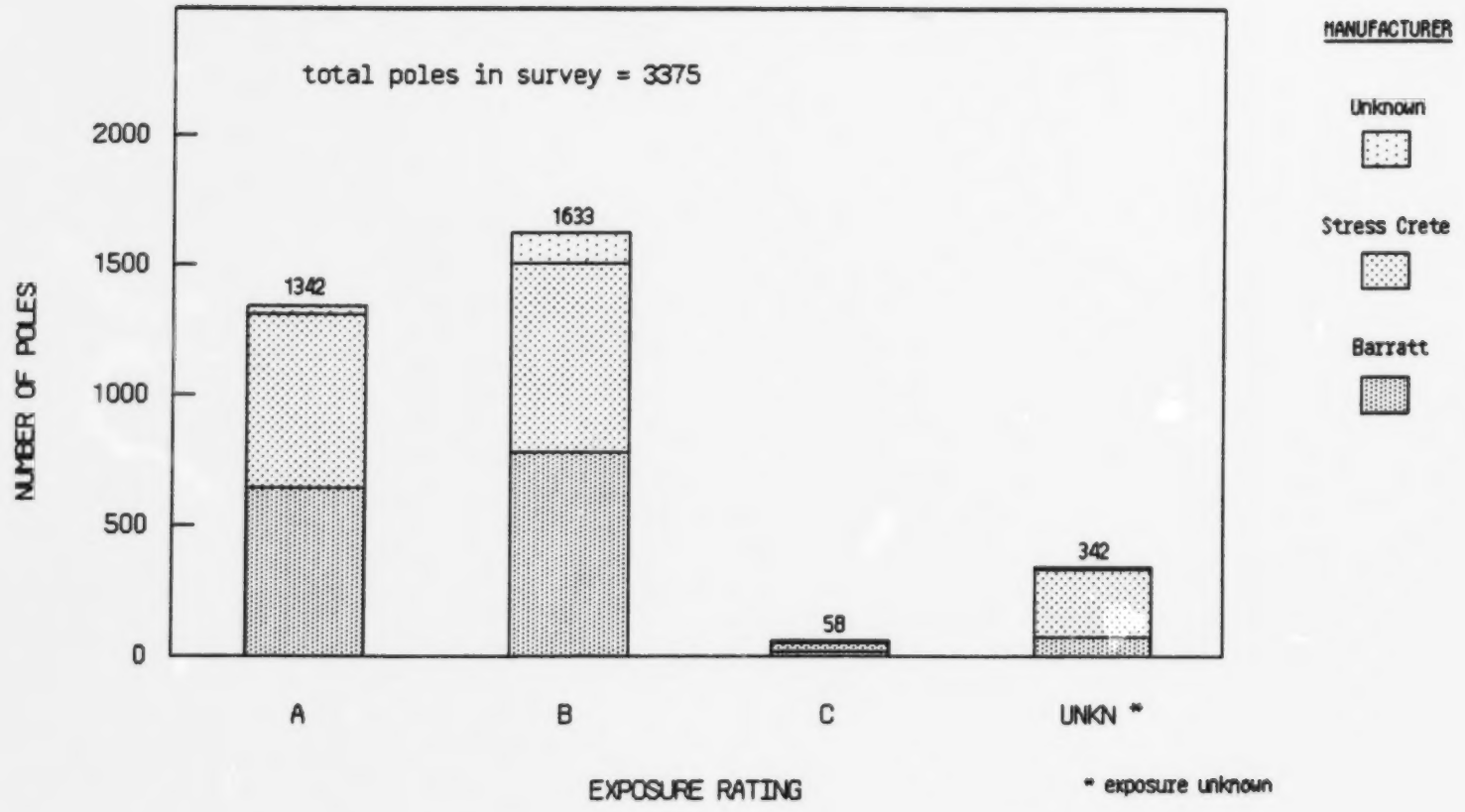

FIGURE 3.3 DISTRIBUTION OF CONCRETE POLES BY EXPOSURE RATING

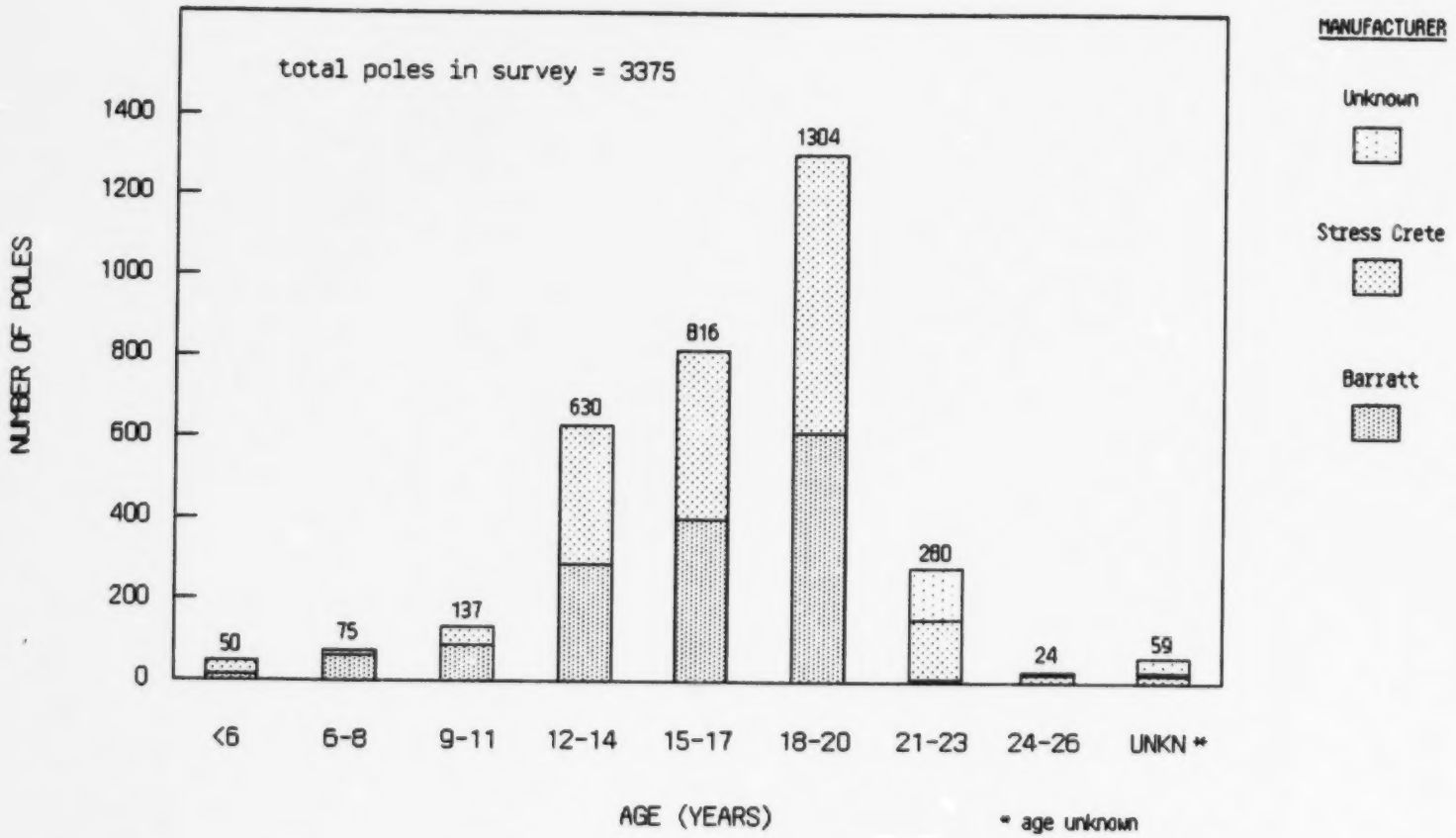

FIGURE 3.4 DISTRIBUTION OF CONCRETE POLES BY AGE (AT TIME OF SURVEY)

years old account for 8 and 11 percent respectively. Figure 3.4 also shows the distribution by manufacturer within each age category.

3.3 Analysis of Concrete Lighting Pole Data

The primary reason for collecting data on concrete lighting poles was to provide an accurate assessment of the condition of the Ministry's in-service poles. Additionally, placing the data on the micro-computer allowed for the examination of trends and relationships between the condition of a pole and its age, manufacturer and exposure to de-icing salt. The findings of this examination are presented in the following sections.

3.3.1 Effect of Age on Concrete Pole Deterioration

As previously stated, it was assumed that the deterioration of a concrete pole is a function of the pole's age, manufacturer, and exposure to de-icing salt. To determine the effect of age on deterioration, the Condition Rating versus pole age was analyzed for poles with the same manufacturer and the same Exposure Rating so that differences in Condition Rating would be accounted for primarily by the difference in the pole's age.

Figure 3.5 presents the distribution by age of poles in the survey with Exposure Rating A. During analysis, Barratt and Stress Crete poles are examined separately. However, since the results did not show any contradictory trends, Barratt and Stress Crete poles were combined for the purpose of Figure 3.5 and 3.6.

Figure 3.5 shows the percentage of poles with Condition Rating 1, 2, 3, 4 and 5 within each of the eight age categories. For example, in the 12-14 year age group the percentages of Condition Rating 1, 2, 3, 4 and 5 were 38, 35, 22, 2 and 3 (total:100 percent) respectively. Given a strong correlation between Condition Rating and pole age, the graph would show a decrease in the percentage of Rating 1 poles with increasing age. The Rating 1 line in Figure 3.5 does show a general decreasing trend up to age 20 and an increasing percentage after that. Therefore, there is not a steady decline in a pole's condition solely because of its age. It should be noted however, that the total number of poles in the 24-26 year category is extremely small (19 poles) in comparison to the

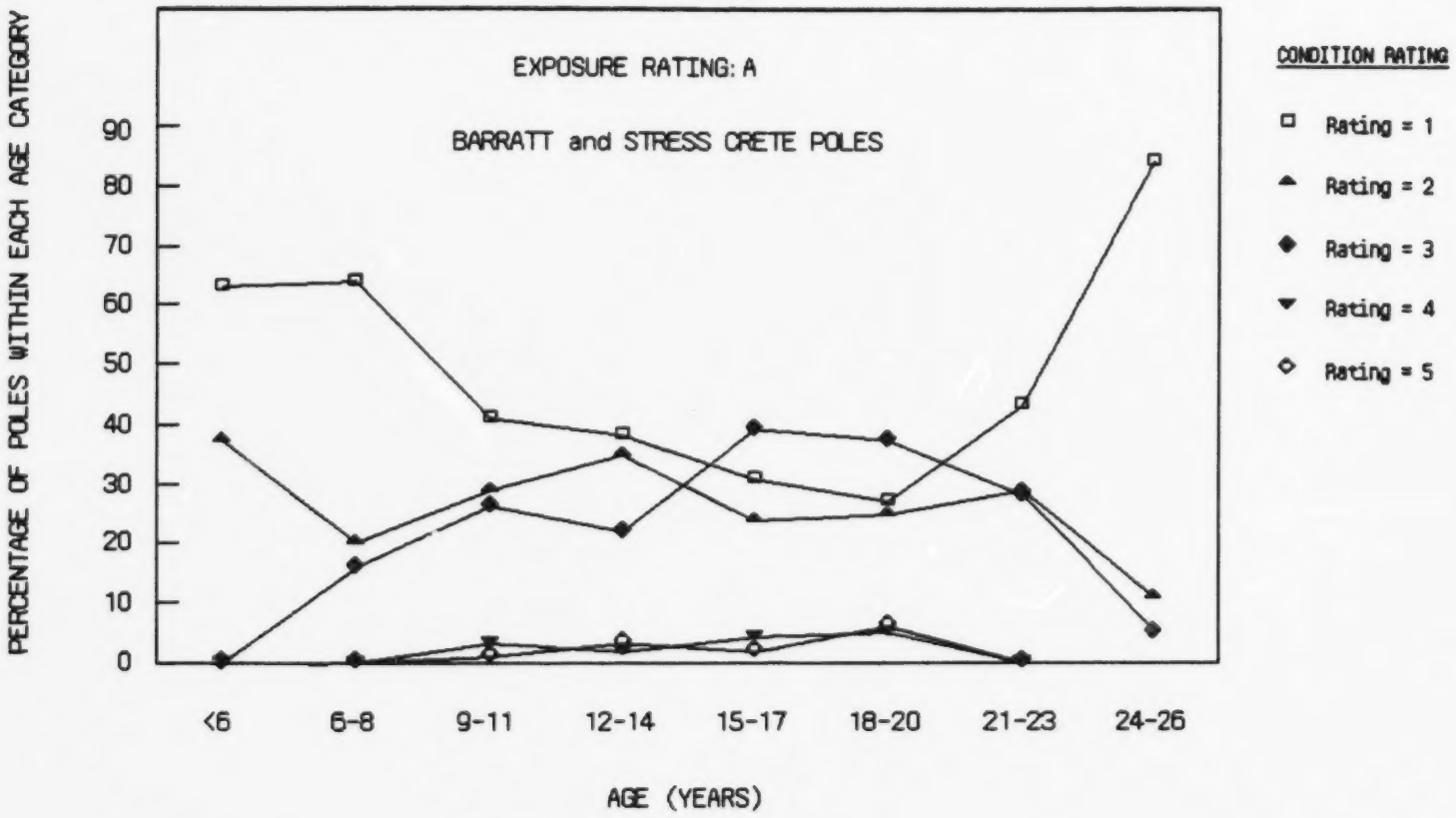

FIGURE 3.5 ANALYSIS OF CONCRETE POLES CONDITION RATING versus AGE

other age categories (e.g. 355 poles in the 12-14 years category) and that the high percentage (84%) of poles with Condition Rating 1 actually represents 16 out of 19 poles.

In general, Figure 3.5 shows that poles under 11 years old are predominantly Condition Rating 1 while poles 11-20 years old have approximately equal percentages of poles with Condition Ratings 1, 2, and 3. Poles over 20 years old are mostly Condition Rating 1. Although these poles represent only a small percentage of the total, it is apparent that well made poles will withstand many years of freeze-thaw cycles and exposure to de-icing salt. It should be noted however, that this high percentage of poles with Condition Rating 1 is a result of previous replacement by District Maintenance staff of most of the badly deteriorated poles in this age group.

Figure 3.6 presents similar information to that of Figure 3.5 for poles with Exposure Rating B. Poles with Condition Rating 1 are predominant for all ages up to 23 years old. Poles with Condition Ratings 2 and 3 show a general increase in percentages with increasing age. Poles with Condition Rating 1 constitute 59 percent of the poles in the 21-23 year age group, re-emphazing the fact that well made poles have the potential for an acceptable service life.

In Figures 3.5 and 3.6 there appears to be no strong relationship between Condition Rating and pole age for those poles with Condition Rating 4 and 5. Figure 3.5 shows that even poles in the 9-11 year age group have reached this level of deterioration. Again, it appears that the quality of fabrication is a more critical factor in concrete pole deterioration than its age. Additionally, there is a higher percentage of poles with Condition Rating 1 for Exposure B conditions than for Exposure A conditions. Therefore exposure to de-icing salt is a predominant factor in concrete pole deterioration. This is further discussed in Section 3.3.2.

3.3.2 Effect of Exposure to De-icing Salt on Concrete Pole Deterioration

The survey data was analyzed in order to determine the impact of de-icing salt on concrete poles. The condition of poles with the same age and manufacturer was compared for poles with Exposure Rating A versus those with Exposure Rating B. This comparison was made of poles within the 12-14, 15-17 and 18-20 year old

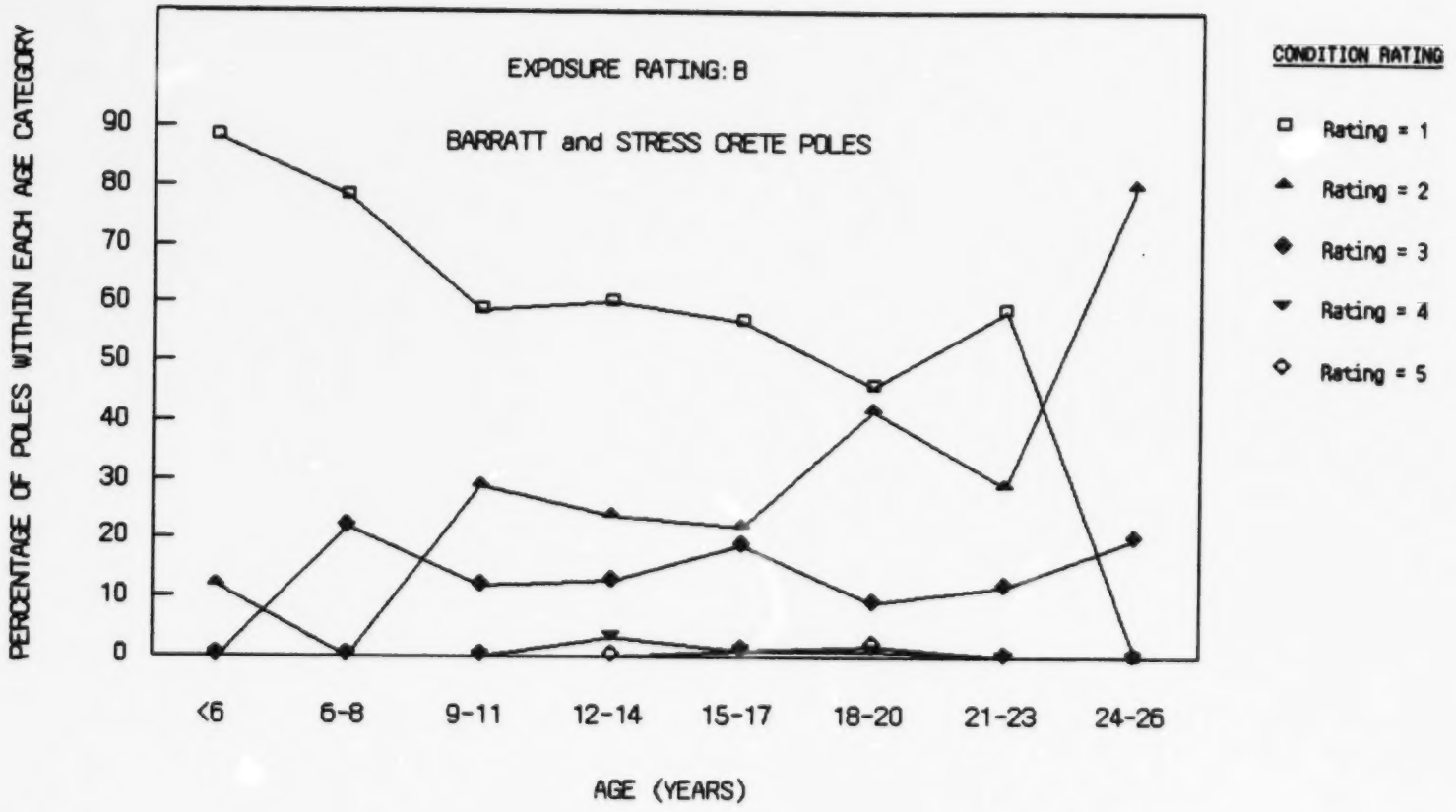

FIGURE 3.6 ANALYSIS OF CONCRETE POLES CONDITION RATING versus AGE

categories because each contains a large sample size. Poles with Exposure Rating C were ommitted from this analysis because of their relatively few numbers.

Figure 3.7 presents the percentage of poles for both manufacturers within Exposure Rating A and Exposure Rating B. In the following section this figure will also be used to compare to performance of Barratt poles versus Stress Crete poles. The impact of very severe exposure to salt spray can be assessed by comparing Barratt poles with Exposure Rating A to Barratt poles with Exposure Rating B. Similarly, one can compare Stress Crete poles with Exposure Rating A to Stress Crete poles with Exposure Rating B. Since the comparison is being made with poles from the same manufacturer and the same age (approximately) the difference in pole performance may be primarily accounted for by the difference in exposure to de-icing salt. From Figure 3.7 the following observations are noteworthy:

1. Barratt poles with Condition Rating 1 accounted for 22 and 55 percent of Barratt poles within Exposure Rating A and B respectively.

2. Barratt poles with Condition Rating 3 accounted for 35 and 18 percent of Barratt poles within Exposure Rating A and B respectively.

3. Stress Crete poles with Condition Rating 1 accounted for 65 and 66 percent of Stress Crete poles within Exposure Rating A and B respectively.

4. Stress Crete poles with Condition Rating 3 accounted for 12 and 7 percent of Stress Crete poles within Exposure Rating A and B respectively.

From these observations it is apparent that conditions of very severe exposure to de-icing salt result in a decrease in the percentage of poles with no noticeable defects (Condition Rating 1) and an increase in the percentage of poles that exhibit some spalling (Condition Rating 3). Also, the impact of the more severe exposure conditions appears to have less effect on Stress Crete poles compared to Barratt poles. This may be explained in part by the fact that Stress Crete poles have proved to be of higher quality in general than Barratt poles. This topic will further be discussed in Section 3.3.3.

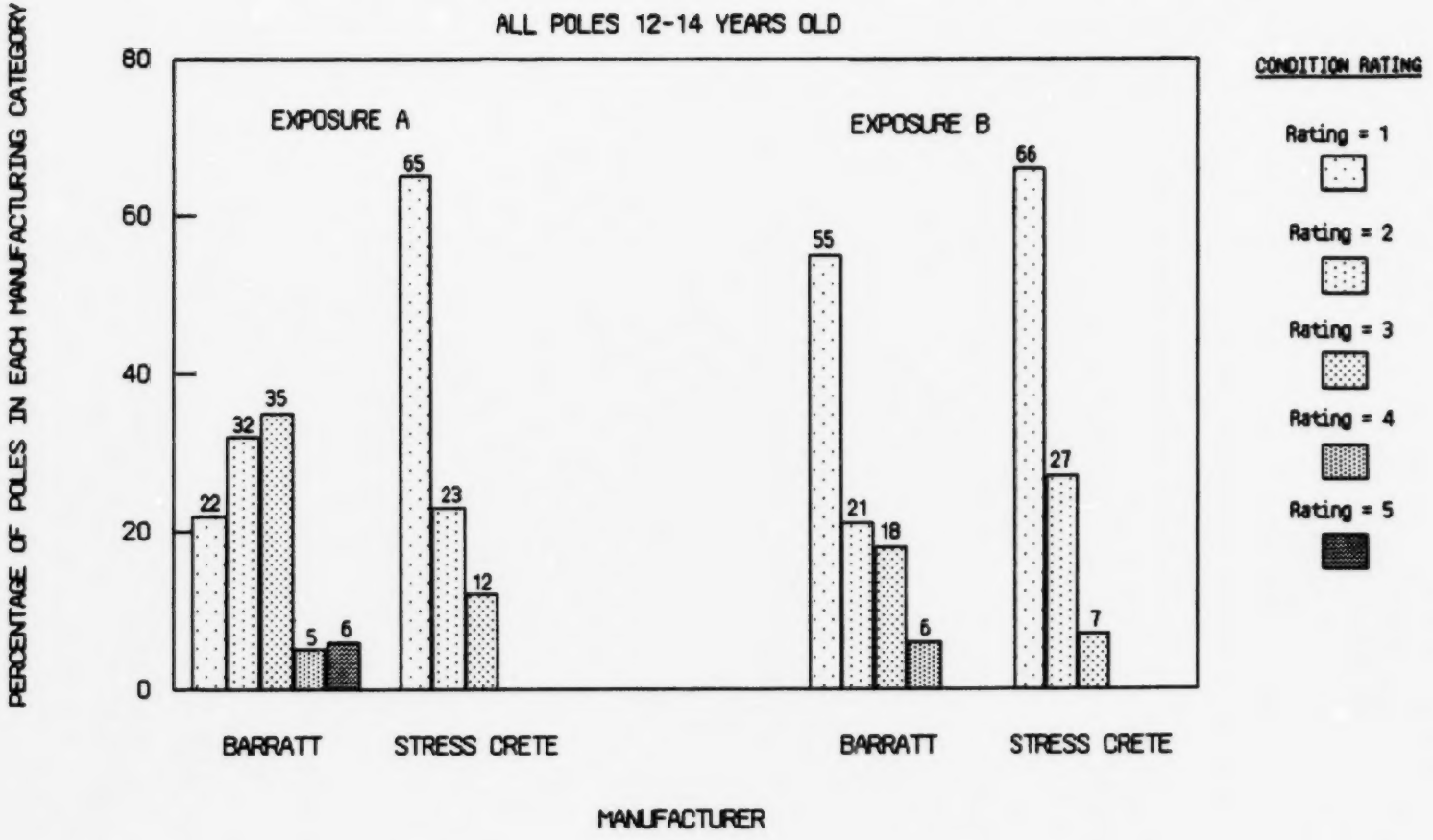

FIGURE 3.7 ANALYSIS OF CONCRETE POLES CONDITION RATING versus MANUFACTURER and EXPOSURE

Figures 3.8 and 3.9 present similar information to Figure 3.7 for poles in the 15-17 and 18-20 year age groups respectively. In Figure 3.8 poles in the 15-17 year age group exhibit similar trends to those discussed above, with the following observations noteworthy:

1. Barratt poles with Condition Rating 1 accounted for 23 and 44 percent of Barratt poles within Exposure Rating A and B respectively.

2. Barratt poles with Condition Rating 3 accounted for 43 and 25 percent of Barratt poles with Exposure Rating A and B respectively.

3. Stress Crete poles with Condition Rating 1 accounted for 38 and 72 percent of Stress Crete poles within Exposure Rating A and B respectively.

4. Stress Crete poles with Condition Rating 3 accounted for 37 and 13 percent of Stress Crete poles within Exposure Ratings A and B respectively.

Again these results highlight the effect of salt spray on the deterioration of concrete lighting poles. Figure 3.9 presents the results of poles in the 18-20 year category. Upon examination of the data presented it may be observed that the same trends are present as discussed above.

3.3.3 Effect of Manufacturer in Concrete Pole Deterioration

Figures 3.7, 3.8 and 3.9 were used in the previous section to examine trends in the Condition Rating as a function of exposure to de-icing salt. These Figures are used in this section to compare poles manufactured by Barratt to poles manufactured by Stress Crete, given poles of approximately the same age and the same Exposure Rating.

From Figure 3.7 (poles 12-14 years old) the following comparisons are made:

1. 22 percent of Barratt poles with Exposure Rating A were surveyed as Condition Rating 1.

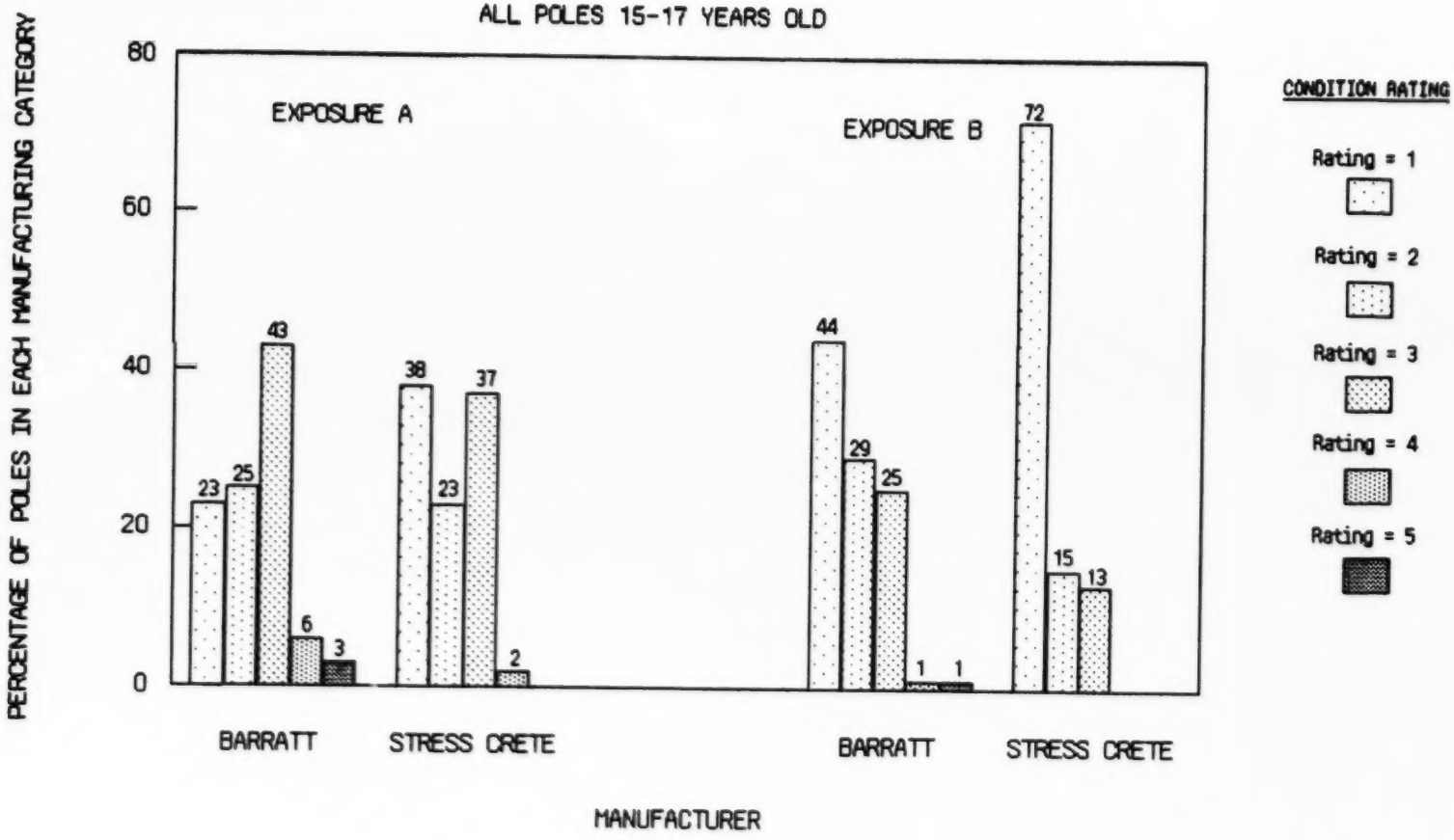

FIGURE 3.8 ANALYSIS OF CONCRETE POLES CONDITION RATING versus MANUFACTURER and EXPOSURE

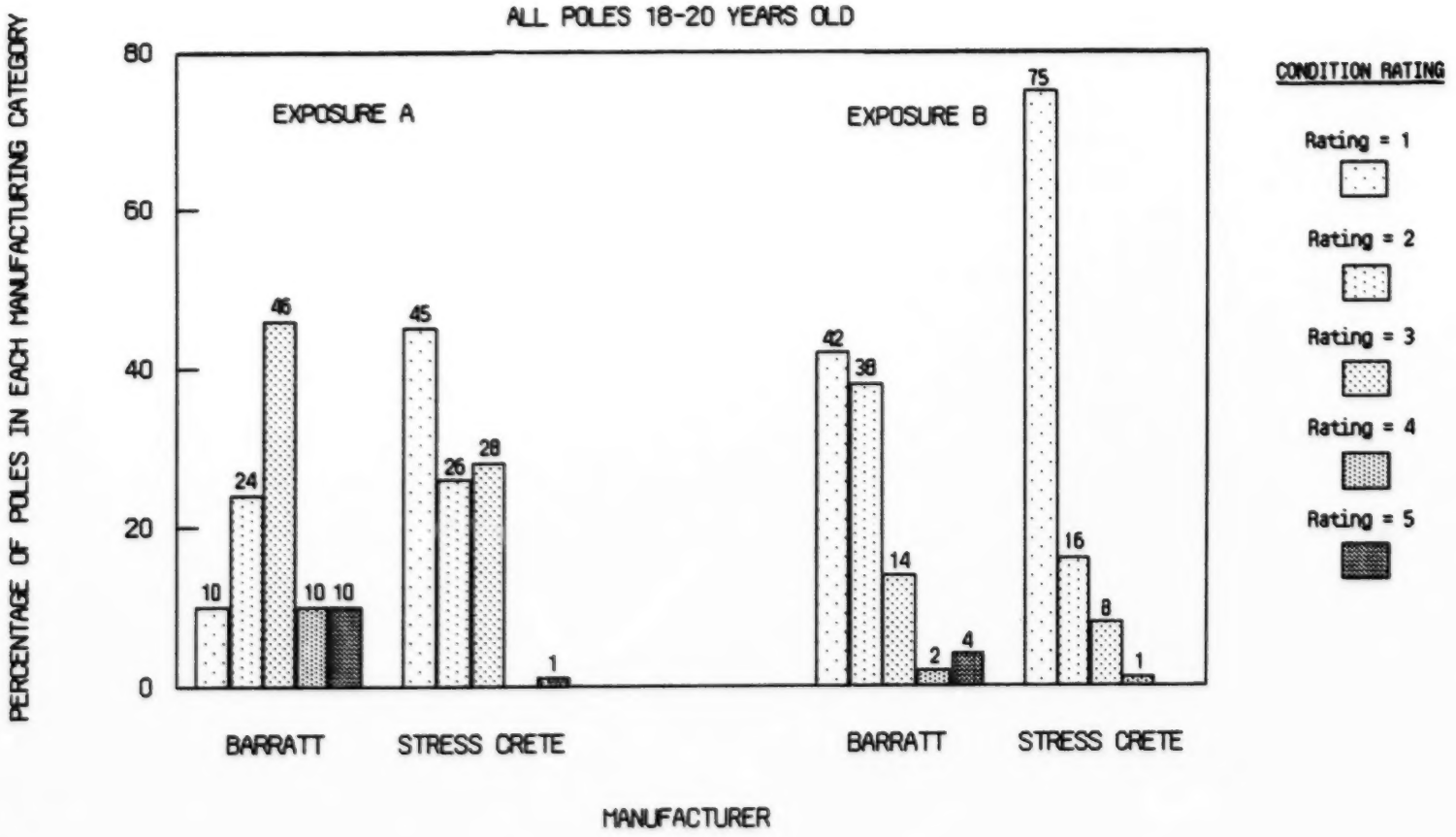

FIGURE 3.9 ANALYSIS OF CONCRETE POLES CONDITION RATING versus MANUFACTURER and EXPOSURE

2. 65 percent of Stress Crete poles with Exposure Rating A were surveyed as Condition Rating 1.

3. 35 percent of Barratt poles with Exposure Rating A were surveyed as Condition Rating 3.

4. 12 percent of Stress Crete poles with Exposure Rating A were surveyed as Condition Rating 3.

These comparisons imply that given poles of the same age and same exposure conditions Barratt poles show a greater incidence of deterioration. Comparing Barratt and Stress Crete poles with Exposure Rating B in Figure 3.7 again shows a greater percentage of Barratt poles with Condition Rating 3 and a smaller percentage of Barratt poles with Condition Rating 1. This trend may also be observed in Figures 3.8 and 3.9 (poles 15-17 and 18-20 years respectively).

4 DISCUSSION OF RESULTS

The results of the survey indicate that more than one-half of the poles surveyed show no noticeable defects. However, additional analysis shows that the average age of poles with Condition Rating 1 (about 16 years) is virtually the same as the average age of poles with Condition Rating 4. It is therefore evident that premature deterioration is a problem, and that the quality of pole fabrication is a much greater factor in its deterioration than the age of the pole. In effect, a 16 year old pole may be in a condition where no defects are visible or, it may be approaching the point where it will soon have to be replaced.

Over half of the poles surveyed were manufactured by Stress Crete while 45 percent were manufactured by Barratt. The data shows that Stress Crete poles are more durable than those produced by Barratt. The data does not however imply that Stress Crete poles perform well, while Barratt poles do not. In fact, both manufacturers have produced poles which remained free of defects for over 20 years as well as poles that have experienced spalling after only 8 years of service. The data simply implies that the incidence of premature deterioration is greater for poles produced by Barratt.

Another factor shown to contribute to the deterioration of concrete poles is spray of de-icing salt. In general, poles with the most severe exposure experience increased deterioration. However, it is evident that poles that were poorly fabricated will be more susceptible to salt spray than poles that were well made. In fact, the survey showed that there are approximately 500 poles with Exposure Rating A (very severe) that have Condition Rating 1 (no noticeable defects). Of these 500 poles, 78 were manufactured in 1964 or earlier.

The large variation in the quality of pole fabrication makes it difficult to forecast the number of poles that will require replacement in each of the next several successive years. A pole may experience constant deterioration throughout its life or it may remain in good condition for most of its life and then deteriorate rapidly. Regardless of the rate of deterioration, it is of concern to District Maintenance staff that there are 659 poles with Condition Rating 3, and therefore are experiencing some spalling. Spalled poles allow for further penetration of de-icing salt and increased corrosion of reinforcing steel necessitating eventual replacement.

5 CONCLUSIONS

Analysis of the data identified the following:

1. The relationship between a pole's age and its condition rating is weak.

2. Stress Crete poles are superior to Barratt poles, although both manufacturers have supplied poles of inconsistent quality.

3. Poles deteriorate at a faster rate in conditions of very severe exposure to de-icing salt than they do in a less severe exposure condition. Poles of poor initial quality are particularly susceptible.

4. Poles that are well made will withstand freeze-thaw cycles and salt spray for over 20 years without showing any signs of defects.

6 REFERENCES

1. Aspinwall D., Status Report, Concrete Illumination Pole Deterioration, District 6 (Toronto) Maintenance Office, Ministry of Transportation and Communications, 1983.